Review article

ISSN:0976-4933
Journal of Progressive Science
Vol.05, No.01, pp 17-26(2014)

# Integrated nutrient management in Cashew for Karnataka region

**T.R. Rupa and Ashok K. Singh[1]**
**Directorate of Cashew Research (ICAR)**
**Puttur-574 202, D.K., (Karnataka), India**

## Abstract

*Cashew is a very important plantation / horticultural crop of India. As cashew is a hardy plant, often it has been thought to be highly suitable for afforestation, soil conservation and waste land development. The cashew plantations raised with this objective, did not receive any management nor inputs, thereby resulting in low productivity. However, research results showed that tremendous positive response can be obtained through regular applications of fertilizers and improved management practices which could give two to three fold yield increases. Cashew requires regular fertiliser application to ensure early and high yields in new plantations, and regular high yields from mature trees. It has been reported that fertigation saved about 50% in fertilizers, while improving the yield and quality as compared with the common methods of fertilizer application. The challenge for cashew crop will be to improve yields in marginal lands and slopy areas where the soil is exposed to degradation strongly limits the growth and production of cashew.*

## 1. Introduction

Cashew (*Anacardium occidentale* L.) occupies an area of 38.17 lakh ha with an annual production of 31.86 lakh tonnes in the world. Cashew production takes place mainly in Central and South American zone, Asia and Oceanic zone and African zone. In the Asiatic zone, Vietnam and India are the major producers. In the African zone, Mozambique, Tanzania and Kenya are the major producers, while the minor cashew producing countries are Benin, Guinea Bissau, Ivory Coast, Madagascar, Nigeria, Ghana, Senega and Togo. In the Latin American zone, the primary producers of cashew comprises of Brazil, Columbia, Costa Rica, Honduras, Salvador, Gautemala, Panama and Venezuela. Cashew was introduced into India by Portuguese travellers in 16th Century for the purpose of afforestation and soil conservation. Cashew is native of Brazil. India was the first country in the world to exploit the international trade of cashew kernels in the early part of 20th Century. India's share of world cashew area is 23.39% and share

[1] Department of Agricultural Chemistry and Soil Scienec, S.M.M.Town P G College, Ballia (UP). India

of world cashew production is 21.81%. India needs about 13-14 lakh tonnes of raw cashewnuts to feed large number of cashew processing units (1800 medium to large and 1850 on-farm level processing units) engaging over 5 lakh workers especially women. As India is producing only 6.95 lakh tonnes of raw cashewnuts annually, the balance quantity of 7.0 lakh tonnes of raw cashewnuts is annually imported by India from African and South East Asian countries. India exports 1.1 lakh tonnes of cashew kernel to over 65 countries in the world. About Rs. 2905 crores is earned as foreign exchange through export of cashew kernel and additional Rs. 24 crores by export of Cashew Nut Shell Liquid (CNSL). Cashewnut is a high value edible nut. Cashew kernels are very tasty as well as nutritious. Cashew kernels contain protein (21%), fat (47%), carbohydrates (22%), minerals and vitamins. Cashew kernel proteins contain all the essential amino acids. Cashew kernels do not contain any anti-nutritional factors. Cashew kernels are free from cholesterol and contain sizeable quantity of mono unsaturated fatty acids (Oleic acid) which is now believed to be as efficient as poly unsaturated fatty acids in lowering blood cholesterol through enhancing the levels of High Density Lipoprotein (HDL) cholesterol and reducing the levels of Low Density Lipoprotein (LDL) cholesterol. Thus, cashew kernel is most safe for consumption. In contrast to the nut, though cashew apple production in the country is about ten times that of nut production, most of the cashew apple is not utilized in India. A small quantity of cashew apple is utilized only in Goa for fenni preparation. A number of processes have been developed for converting the cashew apple into various products such as juice, jam, syrup, chutney and beverage. The CNSL is a versatile industrial raw material with diverse use in friction linings, paints and varnishes, laminating and epoxy resins. There is ever increasing demand for cashew kernel both in international and domestic market. Vietnam and Brazil are competing with India in international market. Since African countries have started processing their raw cashewnuts themselves, availability of raw cashewnuts for importing by India may gradually decline or may all together stop. A few African countries have already taken steps to ban export of raw cashewnuts. Hence, there is an urgent need to increase the domestic raw cashewnut production and become self sufficient in raw cashewnut production. However, some more area which fall under neglected/ degraded soil conditions where other crops cannot come up is available for cashew in different cashew growing states. Increasing area as well as increasing productivity per unit area through adoption of technologies would hopefully make India self-sufficient in production of raw cashewnuts.

## 2. Area, production and productivity trends in last five years

Cashew is currently grown in 8.93 lakh ha in India with about 6.95 lakh tonnes of raw cashewnuts annually. India ranks first in area and production of cashew in the world. Maharashtra, Goa, Karnataka and Kerala along the West Coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal along the East Coast are the major cashew growing states in India. It is also grown to a limited extent in non-traditional areas such as Bastar region of Chattisgarh and Kolar (Plains) region of Karnataka, Gujarat, Jharkhand and in NEH region. Although Andhra Pradesh holds first position in respect of area, Maharashtra stands first position in production and productivity in the country. The average productivity of cashew in India is 0.9 t/ha. However, the productivity level is not increasing over the years as expected as against the new technologies available for adoption. Among several constraints responsible for the low productivity of cashew in India, application of limited or no fertilizer is one of the main reasons in realizing higher yield. In order to visualize the cashew growing scenario in the country, state-wise area, production and productivity of cashew in the last five years (2004-09) is furnished in Table 1. In India, the area, production and productivity during last five years is increasing steadily (Figure 1).

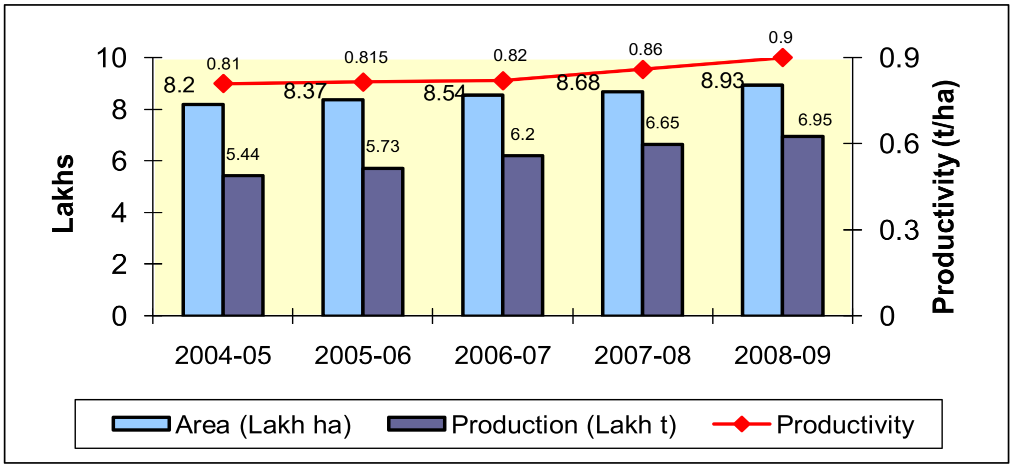


Figure 1. Area, Production and Productivity of Cashew in India

## 3. Important nutrient management aspects including fertigation

The fertilizer requirement of cashew plant warrants more liberal application of nitrogen (N) followed by potassium (K), while phosphorus (P) is needed in comparatively lesser quantity. Nitrogen and P were found to be the most important nutrients during the pre-bearing stage, but at the bearing stage, K together with N is also important. Application of fertilizers, dosage and the time and its schedule under different agro-climatic zones has been standardized (Guruprasad, *et al*.,2009, Kumar *et.al*.,1996,). Studies conducted at National Research Centre for Cashew (Presently Directorate of Cashew Research), Puttur have shown that 500 g N, 125 g $P_2O_5$ and 125 g $K_2O$ per tree per year as the optimum dose for cashew (Yadukumar and Rajani, 2004). Based on the field response in different agro-climatic regions, optimum dose for cashew for different states is given in **Table 2.** It has been reported that a net profit of Rs. 7.21 per rupee invested on fertilizer to cashew. The key to enhance fertilizer use efficiency is to synchronize the time of fertilizer application with the growth need of the crop and period of high root activity. Highest root activity and peak absorption of N, P and K occurred during the 'flushing and early flowering' phase (September to December) and suggested that the onset of this phase is the most appropriate time for fertilizer application in a cashew orchard. Cashew trees are surface feeders with about 50% of the root activity being confined to the top 15 cm of the soil and about 72% of root activity was found within a 2 m radius from the tree trunk (Yadukumar and Rajani, 2004). During the 1$^{st}$, 2$^{nd}$, 3$^{rd}$, 4$^{th}$ and 5$^{th}$ year of planting 1/5$^{th}$, 2/5$^{th}$, 3/5$^{th}$, 4/5$^{th}$ and 5$^{th}$ year onwards full quantity is to be applied.Several researchers have reported the superiority of fertigation in terms of higher scion production and nut yield (Guruprasad, *et.al*. 2009). The number of scions produced/tree and grafting success was highest in the fertigation treatments, i.e. trees supplied with 100% water soluble NPK fertilizers applied through drip irrigation in 4 equal split doses (75.93 scions/tree/year) as compared to without drip irrigation treated plants (37.18 scions/tree/year). Response to irrigation varied among cashew genotypes. Cashew dwarf clones did not respond well to irrigation.

Table 1 Area, production and productivity Trends of Cashew in India, 2004-2009

| State | 2004-05 | | | 2005-06 | | | 2006-07 | | | 2007-08 | | | 2008-09 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (000' ha) | Production (000' mt) | Productivity (t/ha) | Area (000' ha) | Production (000' mt) | Productivity (t/ha) | Area (000' ha) | Production (000' mt) | Productivity (t/ha) | Area (000' ha) | Production (000' mt) | Productivity (t/ha) | Area (000' ha) | Production (000' mt) | Productivity (t/ha) |
| Kerala | 102 | 64 | 0.90 | 80 | 67 | 0.90 | 80 | 72 | 0.90 | 84 | 78 | 0.90 | 70 | 75 | 0.90 |
| Karnataka | 95 | 43 | 0.68 | 100 | 45 | 0.70 | 102 | 52 | 0.70 | 103 | 56 | 0.71 | 107 | 60 | 0.72 |
| Goa | 55 | 26 | 0.66 | 55 | 27 | 0.69 | 55 | 29 | 0.69 | 55 | 31 | 0.70 | 55 | 30 | 0.70 |
| Maharashtra | 160 | 174 | 1.20 | 160 | 183 | 1.30 | 164 | 197 | 1.50 | 167 | 210 | 1.50 | 170 | 225 | 1.50 |
| Tamil Nadu | 105 | 53 | 0.61 | 121 | 56 | 0.64 | 123 | 60 | 0.67 | 123 | 65 | 0.70 | 131 | 68 | 0.71 |
| Andhra Pradesh | 150 | 88 | 0.84 | 170 | 92 | 0.88 | 171 | 99 | 0.89 | 171 | 107 | 0.90 | 182 | 112 | 0.92 |
| Orissa | 126 | 74 | 0.81 | 120 | 78 | 0.86 | 125 | 84 | 0.86 | 131 | 90 | 0.86 | 137 | 95 | 0.865 |
| West Bengal | 9 | 8 | 0.80 | 10 | 10 | 0.95 | 10 | 10 | 1.00 | 10 | 10 | 1.00 | 11 | 11 | 1.00 |
| Gujarat | - | - | - | 4 | 4 | 0.90 | 4 | 4 | 0.90 | 4 | 4 | 1.00 | 6 | 4 | 0.70 |
| NE States | - | - | - | 14 | 10 | 0.64 | 15 | 11 | 0.70 | 15 | 12 | 0.75 | 16 | 12 | 0.75 |
| Others | 18 | 14 | 0.80 | 3 | 1 | 0.40 | 5 | 2 | 0.50 | 5 | 2 | 0.50 | 8 | 3 | 0.46 |
| Total | 820 | 544 | 0.81 | 837 | 573 | 0.815 | 854 | 620 | 0.82 | 868 | 665 | 0.86 | 893 | 695 | 0.90 |

Table 2. Fertilizer recommendations (g/tree/year) for cashew in different states

| **State** | **N** | **$P_2O_5$** | **$K_2O$** |
|---|---|---|---|
| Kerala | 500 | 125 | 125 |
| | 750 | 325 | 750 |
| Karnataka | 500 | 250 | 250 |
| | 500 | 125 | 125 |
| Maharashtra | 1000 | 250 | 250 |
| Tamil Nadu | 500 | 200 | 300 |
| Andhra Pradesh | 500 | 125 | 125 |
| Orissa | 500 | 250 | 250 |

Source : Harishu and Shridharan (1986)

Application of 750 : 187.5 : 187.5 g of NPK/tree along with irrigation at a rate of 60-80 L of water once in four days through drip during flowering and fruit development resulted in higher yield. Fertigation saved 50% in the fertilizer requirement and doubled the cashew yield. Highest profit of Rs.27,294/ha (with B:C Ratio of 3.71) was obtained with the application of half of recommended dose of nutrients through fertigation and balance half applied in the form of castor cake to soil, while the profit was Rs. 8,995 when the NPK dose was given to soil. Water soluble fertilizers like urea, DAP and MOP are used for fertigation through drip lines from December to March and application of 2 kg castor cake to soil during August. Fertigation is done once in a week from December to March. With fertigation quantity of nutrients (through fertilizers and organic manures) to be applied can be reduced to half of the quantity of recommended nutrients. Yield can be increased from 1 t/ha in case of high density planting without irrigation to 2 t/ha with fertigation of $1/4^{th}$ of the recommended Fertilizer nutrients and remaining$1/4^{th}$ applied to soil in the Form of castor cake. The peak water requirement (peak nut set) for 5 year old trees, growing in sandy soil and under high evaporative demand, is about 400-500 L/tree/week. Large reductions in yield, tree size and yield efficiency were associated with a lack of fertilizer and irrigation (Sapkal, 2000).

## 4. Soil related constraints and nutrient deficiency scenario-

Cashew being a hardy plant, can thrive in a wide variety of soils and usually found allotted to marginal wastelands. In India, cashew is grown mainly on laterite, red and coastal sands in the states of Kerala, Maharashtra, Goa, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. It is also grown on black soils in Tamil Nadu and Andhra Pradesh to a limited extent. Though it is grown in almost all types of soils, it performs better in well drained, brown forest soils, red sandy loam and light coastal soil with a high water holding capacity and rich in organic matter. Cashew prefers slightly acid soil of pH 4.5 to 6.5, with low calcium (Ca) content. Red and lateritic soils are generally acidic and have low CEC, low to moderate base saturation. Due to intensive leaching and presence of high amounts of iron and aluminum oxides, the soils show deficiency of nutrients, such as N, P and K causing nutrient imbalances. Surface crusting, excessive gravelly texture, nutrient imbalances, soil erosion and inundation in coastal ecosystem are the major constraints in these soils. Soil acidity and kaolinitic nature of the clay mineral makes for phosphate fixation of water soluble P but allows the use of rock phosphate as a good source of P to cashew crop. Since some soils under cashew are very acid, iron (Fe) and aluminum (Al) toxicity is a distinct problem. Magnesium (Mg) assumes significance for cashew in coarse textured soils. Zinc (Zn) deficiency is widespread in all soils under cashew. Deficiencies of Mg, Zn, boron (B) and molybdenum (Mo) are more likely common in acid soils. Liming these acid soils increases the availability of nutrients and is a common procedure for correcting micronutrient deficiency. Application of inorganic fertilizers P, K and B along with dolomite limestone resulted in rise in soil pH and thereby enhanced the plant available nutrient pools (Badinath *et.al*.1985). Information provided on the fertility status of cashew soils in Dakshina Kannada district (Karnataka) indicated that the soils were acidic, normal in electrical conductivity, high in organic carbon, medium in available P, low in available K and dominated by kaolinitic type of clay minerals (Beena, *et al*.1995b). Of the micronutrients, Zn and B were highly deficient in cashew growing soils of Dakshina Kannada (Karnatka) (Badrinath *et.al*. 1985)). Cashew cannot grow and yield properly in saline soils. Electrical conductivity of irrigation water 1.48 dS $m^{-1}$ is a threshold tolerance for precocious cashew during the initial growth. Higher soil temperature and density resulted in reduction of plant growth as well as roots of the cashew. Flowering of cashew requires mild winter and the availability of soil moisture plays a key role in kernel development (Yadukumar *et.al*.2003)). Cashew can tolerate mild to moderate levels of moisture stress without affecting the growth of seedlings (Souza *et al*., 2003). Strong and severe water stress resulted in 20 and 22% reduction in number of scions, respectively. Cashews grown in west coast of India are mostly on undulating terrain thereby proned to runoff and soil erosion due to heavy rainfall. Under medium to steep slopes, soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments have helped in conserving soil moisture, reducing the annual runoff / soil loss and increasing the nut yield (28, 45, 46). The trapezoidal shaped staggered trenches (230/ha) having dimensions of 4.5 m length, 0.60 m top width, 0.30 m bottom width and 0.30 m depth were effective for reducing runoff and conservation of soil and nutrients (3). It was demonstrated that continuous contour trench (0.50 m x 0.60 m) is the best soil conservation practice for cashew on areas having 7 to 8 per cent slope (Mohapatra *et.al.*1973).

## 5. Nutrient removal and addition, balance Sheet-

A considerable amount of nutrients is removed annually by the cashew tree. The amount of nutrients removed by a cashew tree (30 year old) are listed in **Table 3**. The analytical results also revealed that in production of one kg of cashewnut, 64.1 g N, 2.05 g P, 24.7 g K, 4.19 g Ca, 1.57 g S, 525.7 mg Fe, 63.6 mg Mn, 87.8 mg Zn and 26.5 mg Cu per tree is removed by the apple and nut (Blaikie, *et.al.* 2001). The annual nutrient uptake required by Australian cashew trees of 70 months of age were 2.1 kg N, 0.45 kg P, 1.32 kg K, 0.54 kg Ca and 0.57 kg Mg in order to maintain the structure of the tree. An eight year old cashew tree removes 610 g N, 58 g P, 394 g K, 52 g Ca, 39 g Mg, 34 g S, 2.12 g Fe, 343 mg Mn, 390 mg

Zn and 130 mg Cu in Australia. The order of nutrients removed by the cashewnuts and the apple was N > K > Mg > P > S > Ca and K > N > Mg > P > S > Ca, respectively.

Table 3. Estimated removal of nutrients (kg/tree) by a cashew tree

| Plant parts | N | P (as $P_2O_5$) | K (as $K_2O$) | Average NPK ratio |
|---|---|---|---|---|
| Leaf, stem and root | 1.721 | 0.406 | 0.800 | 4 : 1 : 2 |
| Fruit (155 kg) | 0.370 | 0.117 | 0.282 | 3.2 : 1 : 2.4 |
| Nuts (24 kg) | 0.756 | 0.229 | 0.183 | 3.3 : 1 : 0.8 |
| Total | 2.847 | 0.752 | 1.265 | 3.8 : 1 : 1.7 |

Source : NRC Vision-2025 ( 2003)

The amounts of nutrient elements recycled in canopy fallout may partially meet the nutrient requirements of cashew. About 15.5–37.7% of tree total requirements of macro-nutrients are recycled from canopy biomass fallout of leaves, cashew apples and flowers from six year old cashew trees in Australia (Sapkal,2000). Studies conducted at Directorate of Cashew Research, Puttur on nutrient budgeting and nutrient balance in a six year old cashew plantation of 'Bhaskara' variety under high density planting system (625 trees/ha) showed a negative N, P and K balance of 113, 38 and 92 kg/ha in control plot where no fertilizer was applied. A strong positive N, P and K balance ranged from 128 to 253, 18 to 54 and 34 to 128 kg/ha were recorded in plots with 2/3$^{rd}$ and full dose of recommended fertilizers (750 g N and 150 g each of $P_2O_5$ and $K_2O$ per tree/year).

## 6. Soil test based nutrient recommendations

Information about soil test based nutrient recommendations in cashew is very limited. The present system of nutrient recommendation to cashew in different states is based on general recommendation. Quantitative Estimation of Soil Fertility and Fertilizer Recommendations (QUEFC) for cashew was developed using MS Excel to estimate the fertilizer N, P and K requirement of cashew for different soil fertility regimes, yield levels and tree ages. In this model, the dose of fertilizer N is depending on soil available N content and nut yield. The fertilizer doses of P and K are depending on nut yield. This model demands three inputs namely available nitrogen content in the soil (kg/ha), expected yield level (kg/tree) and age of the tree for formulating site specific fertilizer requirements of cashew (Shingre *et.al*., 2003).

## 7. Balance use of plant nutrients to improve crop yield and quality

Information about balance use of nutrients in cashew is very meager. Absence or scarcity of essential elements in the soil cause deficiencies in the tree and so affect vital processes. Limited or no use of fertilizers and organic manures leading to multiple deficiencies is one of the several factors of low productivity. Recycling of cashew litter, use of microbial inoculants for mobilizing nutrient from difficult soil pools, foliar nutrient spray and plant growth promoters can enhance and sustain the soil heath and cashew productivity. The root stocks and grafts of cashew supplied with 150:20:100 ppm of NPK at a rate of 100 ml/plant/week had higher plant height, stem girth and number of leaves. The NP ratio found optimum for young cashew trees was 2:1 (Shivprasad, *et.al*.1992). Application of mineral nutrients in combination with organic fertilizers significantly increased the height, dry matter weight of aerial parts and the numbers of leaves of cashew seedlings (Manjunath, 2001). Foliar sprays of nutrients (urea 2 to 4%; DAP 1%; orthophosphoric acid; $ZnSO_4$ 4%; Cu 0.3 to 0.6%) at the emergence of the flush, panicle initiation and fruit set stages ensure better fruit set and also enhance nut yield in cashew. Yellow leaf spot in low soil pH (4.5-5.0) could be corrected by foliar sprays of molybdenum (Mo) salts. Foliar spray of growth regulators Planofix, Nutron, IAA, IBA, NAA, 2,4-D and ethrel were effective in increasing the total number of flowers, hermaphrodite flowers, sex ratio, fruit and yield per panicle, and also improve physico-chemical composition of apples and nuts (Grundon, 2001).

## 8. Integrated nutrient management recommendations for higher yield and profit

Cashew responds well to fertilization. Nitrogen and P were found to be the most important nutrients during the pre-bearing stage, but at the bearing stage, K together with N is also important. Organic manure must be applied at planting, addition of farmyard manure (FYM) at a rate of 6 t/ha provides for the better growth of young plants. Green leaf manuring with glyricidia and sesbania in cashew resulted in higher nut yield and improvement in soil nutrient content. In studies on integrated nutrient management in cashew conducted at Directorate of Cashew Research (DCR), Puttur showed that application of 500 g N and 125 g each of $P_2O_5$ and $K_2O$ and 10 kg poultry manure per tree per year under normal density planting system (200 trees/ha) and 250 g N and 50 g each of $P_2O_5$ and $K_2O$ and 10 kg poultry manure per tree per year under high density planting system (625 trees/ha) is found superior in terms of higher nut yield for rainfed cashew. *Azospirillum* inoculation with compost of organically recyclable biomass available in cashew garden produced significantly more nut yield and profit than the nutrients applied in inorganic form. Organic production of cashew offers immense potential. Cashew plantations have vast potential of organic biomass available for recycling. The availability of cashew leaf litter from different age group plantations (10 to 40 years) ranged from 1.38 to 5.20 t/ha (Harishu, 1986). Vermicomposting of cashew leaf litter and apple by using local earthworm *Eudrillus spp.* has been standardized at DCR, Puttur. About 5.5 tonnes of available cashew biomass waste per ha can be converted into 3.5 tonnes of compost or vermicompost and helps in meeting nutrient requirement to cashew by 50%. The use of biofertilizers is of relatively recent origin. Application of *Azospirillum*, *Azotobacter* and Vesicular Arbuscular Mycorrhizae (VAM) increased the germination percentage of nuts and plant growth, and reduced the incidence of fungal diseases in the nursery (Kumar *et. al*.1996). Inoculation of *Azotobacter* resulted in higher root growth and yield of cashew. Among VAM, *Acaulospora laevis* and *Gigaspora mosseae* are better symbionts for inoculating cashew. It has also been reported that among VAM, *Glomus fasciculatum* is superior in terms of increased shoot length, internode number, number of leaves, stem diameter, root length and root number under nursery conditions (Ankaiah and Rao,1987). *Glomus fasciculatum* is more effective to enhance growth and P uptake of cashew plants. VAM (25 g/bag) is helpful for better graft uptake at the time of grafting .

## 9. Constraints and remedies

a) **Constraints-** There are some constraints in cashew production in the country which limits the productivity of cashew per unit area. Following are the probable reasons for low productivity:

- Senile and seedling origin plantations of non-descript types with low yield. This situation mostly exists in cashew plantations under govt. owned Cashew Corporations and Forest Corporations.

- Cashew is a neglected plantation crop among the farmers and hence grown under neglected conditions.
- The land which is not suitable for other plantation crops are only available to cashew crop. Hence, the land which is available for cashew is usually eroded and degraded lands with poor soil fertility.
- Farmers are not fully aware of the latest cashew production technology due to inadequate transfer of technology.
- Even if farmers are aware of the latest Cashew Production Technology, non adoption of recommended package of practices to the extent required.

**b) Probable Remedies**

- Increasing production per unit area.
- Adopting integrated nutrient management strategies to improve yield and quality of nut.
- Reducing the cost of production of raw cashewnuts to become competitive in the global market by practising balanced nutrition and fertigation to cashew.

## 10.Conclusions and Future Research Needs

a) **Conclusions-**Cashew is one of the most important plantation crops grown in India. Cashew was earlier considered as waste land crop suitable only for growing in eroded and degraded lands. Bulk of the soils growing cashew in India are lateritic, red and coastal sands which are poor in soil fertility. The runoff and soil erosion are very high in steep slopes. The crop is seldom fertilized by the farmers. The average productivity of cashew in India is moderate (0.90 t/ha), which is a matter of great concern. The above discussion clearly illustrates the importance of fertilizers, manures and biofertilizers and, soil and water conservation measures in cashew nutrition. Application of nutrients through irrigation water is essential to enhance nutrient use efficiency and also to realize high yields on a sustained basis.

**b) Future research needs**

- Need to generate information on balanced nutrition on yield and quality of cashew.
- Need for identification of nutrient constrains in cashew growing soils for taking remedial measures.
- Development of farmers' resource based integrated plant nutrient supply system for cashew based cropping systems.
- Developing of Integrated nutrient management package for cashew with respect to age and varieties.
- Development of models for predicting nutrient response in cashew.
- Need to develop soil test and crop response based fertilizer recommendations for cashew based cropping system.

## References


1. Ankaiah, S. and Rao, P.V. (1987).*Indian Cashew J.* 15(3), 9-11
2. Badhe, V.T. and Magar, S.S. (2004). *Indian J. Soil Conservation,* 32(2),143-147
3. Badrinath, M.S., Sudhir, K. and Chikkaramappa, T. (1997). *The Cashew,* 11(2), 22-27
4. Badrinath, P., Sridhar Herle, A.M., Krishnappa., Patil, B.N. and Balakrishna Rao, K. (1985).*Cashew Causerie*, 7(4): 9-10
5. Badrinath., Krishnappa, A.M., Patil, B.N., Balakrishna Rao, K. and Janardhana Gowda, N.A. *Cashew Causerie,* 8(2), 14-15 (1986).
6. Beena Bhaskar., Abdul Salam, M., and Wahid, P.A.(1995a). *J. Plantation Crops,* 23(1), 35-39 .
7. Beena Bhaskar., Salam, M.A. and Wahid, P.A.(1995b). *The Cashew,* 9(3), 9-16 .
8. Blaikie, S.J., Chacko, E.K. and Lu, P.(2001). *Australian J. Experi. Agric.* 41(5), 663-673 .
9. Carneiro, P.T., Fernandes, P.D. and Gheyi, H.R.(2002). *Revista Brasileira De Engenharia Agricola E Ambiental* 6(2), 199-206 .

10. Fragoso, H.A. (1999). Revista Brasileira De Ciencia Do Solo 23(3), 603-608 .
11. Ghosh, S. N.(1988). *Indian Cashew J.* 19(1), 19-23 .
12. Grundon, N. J.(2001). A desktop study to predict the fertilizer requirements of cashew trees in Northern Australia. CSIRO Land and Water, Atherton, Technical Report 32/01.
13. Guruprasad, T.R., Hanumanthappa, M., Sudhir, K.V. and Dhananjaya, B.(2009). *The Cashew and Cocoa J.* 1(3), 18-22 .
14. Harishu Kumar, P. and Sreedharan, C. (1986). *Indian Cashew J.* 18(2), 15-17
15. Kumar, D.P., Hegde, M. and Guruprasad, T.R. (1998).*Cashew Bulletin*, 35(4), 2-4
16. Kumar, D.P., Hegde, M., Khan, M.M. and Shivashankar, K. (1996). Proc. of the12th Symposium on Plantation Crops, Kottayam, India, 27-29-November 1996
17. Lakshmipathy, R. (2000). *The Cashew*, 14(3), 20-24
18. Latha, A. and Salam, M.A. (2003).*The Cashew,* 17(3), 17-20
19. Mane, M. S., Mahadkar, U. V., Ayare, B. L. and Thorat, T. N. (2009).*Indian J. Soil Conservation,* 37(3), 181-184
20. Manjunatha, D. (2001).*The Cashew*, 15(1): 13-18
21. Mohapatra, A.R., Vijayakumar, K. and Bhat, N.T. (1973).*Indian Cashew J.* 9(2): 19-20
22. Nawale, R.N., Sawke, D.P. and Salvi, M.J. 9 (1985).*Cashew Causerie,* 7(3), 8-
23. NRC-Cashew Vision – 2025 (Eds: Dr. K.V. Nagaraja, Dr. P.S. Bhat and Dr. M.G. Bhat), (2007). National Research Centre for Cashew, Puttur 574202, D.K., Karnataka. 46 p
24. Oliveira, V.H. de., Barros, L. de M. and Lima, R.N. (2003). *Pesquisa Agropecuaria Brasileira,* 38(1), 61-66
25. Rao, G.S.L.H.V.P., Giridharan, M.P. and Jayaprakash Naik, B. (2001). *The Indian J. Agric. Sci.* 71(6), 399-402
26. Richards, N.K. Cashew response to water and nutrients in a sandy red earth soil of the Northern Territory. Technical-Bulletin-Northern-Territory,-Department-of-Primary-Industry-and-Fisheries. 1993; (202): 17-38.
27. Yadukumar, N., Raviprasad, T.N., Nagaraja, K.V., Haldankar, P.M., Godase, S.K., Susanamma, K., Gajendran, G., Mahalingam, T., Lenka, P.C., Mohapatra, R.N. and Bandyopadhyay, B. (2003). National Agricultural Technology Project. Final Report on developing integrated production packages for enhancing productivity of cashew. National Research Centre for Cashew, Puttur, D.K., Karnataka. 95 p
28. Salam, M. A., John, P. J., Joseph, M., Poduwal, M., Kumar, P., Yadukumar, N. and Bhat, M.G. (2008).*J. Plantation Crops,* 36(2), 86-94
29. Sapkal, B.B.(2000). *The Cashew* 14(1), 41-44
30. Shingre, D.V., Gawankar, M.S. and Jamadagni, B.M. (2003).*The Cashew*, 17(1), 19-22
31. Singh, S.K., Syamal, M.M., Maurya, A.N. (1992).*The Cashew*. 6(2), 11-12
32. Singh, S.N. (1997).*Environment and Ecology,* 15(2), 482-484
33. Sivaprasad, P., Sulochana, K.K., George, B., Salam. M.A. (1992).*The Cashew,* 6(1), 16-18
34. Souza, I.H., Andrade, E.M. and Bezerra, F.M.L. (2004). *Proc. of the Inter-American Soc. for Tropical Horti.* 47, 157-160
35. Veeraraghavan, P.G., Celine, V.A., Balakrishnan, S. (1985). *Cashew Causerie,* 7(2), 6-8
36. Venkattakumar, R., Yadukumar, N. Bhat, P.S. and Gopalakrishna Bhat, M. ( 2003).Cashew Production Technology, National Research Centre for Cashew, Puttur, Karnataka. 36 p
37. Vidyachandra, B. and Hanumashetti, S.I. (1984).*Indian Cashew J.* 16(2), 17-18
38. Wahid, P.A., Kamalam, N.V., Ashokan, P.K. and Vidyadharan, K.K. (1989).*J. Plantation Crops,* 17(2), 85-89
39. Yadukumar, N and Nandan, S. L. (2005).*J. Plantation Crops*, 33(2), 99-102
40. Yadukumar, N and Rejani, R. (2006). *J. Plantation Crops,* 34(3), 364-367
41. Yadukumar, N and Rejani, R. (2008). Soil and water management in cashew plantations – Technical Bulletin (10). NRC-Cashew, Puttur, Darbe (PO), D.K., Karnataka. 20 p
42. Yadukumar, N. (2004).*The cashew,* 18(4), 29-38
43. Yadukumar, N. Rejani, R. and Prabhakar, B. (2009).*J. Plantation Crops,* 37(2), 108-121
44. Yadukumar, N., Rejani, R. and Nandan, S.L. (2008). *J. Plantation Crops,* 36(3), 265-269


**Received on 19.05.2013 and accepted on 12.06.2014**